91-03634/

GEOLOGY OF THE THIRD PORTAGE LAKE AREA NORTH OF BAKER LAKE, DISTRICT OF KEEWATIN, NWT

A. E. Armitage
and
R. S. James

Laurentian University, Sudbury Ontario
P3E 2C6

NWT GEOLOGY DIVISION - NAP
Box 1500 - Yellowknife

Indian and Northern Affairs Canada
Affaires indiennes et du Nord Canada

EGS 1990-14 Geology of the Third Portage Lake area, North of Baker Lake, District of Keewatin, NWT parts of NTS 66 H/1 by A.E. Armitage and R.S. James 1 text, 17 p.

Price: $1.00

INTRODUCTION

In this report we describe the geology of a 6km² area centred on Third Portage Lake which forms the basis of an MSc thesis by the senior author at Laurention University, Sudbury Ontario. The study area is located 80km north of Baker Lake (Fig. 1) in the southeast corner of the Amer Lake map sheet (NTS 66H/1), N.W.T. The rocks in the study area are Archean in age (2.8 Ga) and lie within the Rae province (Hoffman 1988) of the Canadian Shield.

Ashton (1988) has completed the most recent study on the rocks in the southern half of the Amer lake map sheet which includes the Archean supracrustal rocks of the Woodburn Lake Group. These rocks consist of a sequence of metavolcanic and related metasedimentary rocks and younger quartzites. The metavolcanic rocks are dominated by felsic to intermediate tuffs and flows, and lesser amounts of mafic and ultramafic volcanic rocks. Metagabbros of several ages are locally common as sills and dykes throughout the volcanic sequence. Metasediments consist of greywackes, oxide facies banded iron formation and rocks of the quartzite unit including phyllites, mica schists, conglomerates and orthoquartzites. This supracrustal sequence has been intruded by a late Archean (2.6 Ga) granitoid plutonic complex which consists of numerous coarse grained granite plutons. Late biotite porphyry dykes (lamprophyres) crosscut rocks of the metavolcanic sequence and some of the granite intrusions. The metamorphic grade has reached the biotite zone of the greenschist facies in most of the study area, and the hornblende hornfels facies adjacent to the late granite plutons. Several phases of folding and faulting have deformed the rocks in this terrain.

Geologic mapping at a scale of 1:25000 was completed by the senior author during August, 1989: NTS coordinates of the Third Portage Lake area are 65° 00° and 65° 05° N and 96° 00° and 96° 10° W. The primary objective of this study is to describe the geology and petrology of rocks associated with mineralized banded iron formation which is common in this area. The mineralization has most recently been outlined by Comaplex Mineral Corporation, Calgary during an exploration program in the summer of 1989. Funding for the project has been provided by the Department of Indian Affairs and Northern Development (DIAND) located in Yellowknife, N.W.T. Field support was provided by Comaplex Mineral Corporation during the month of August; field assistance was provided by Rick Walker, Calgary.

GEOLOGIC UNITS OF THE THIRD PORTAGE LAKE AREA

In Figure 2, a map of the geology of the Third Portage Lake area is presented at the scale 1:30000. The majority of the rock units in this area are members of the Woodburn Lake Group and consist meta-volcanic and related meta-sedimentary units. The meta-volcanic rocks are dominated by felsic meta-volcaniclastics and minor felsic and mafic flows. Banded magnetite-chert iron formation (BIF) is interlayered with the meta-volcanic rocks. Chlorite-epidote-carbonate schist locally occur as isolated outcrops in the felsic meta-volcaniclastic unit and as narrow zones adjacent to the quartzite unit in several locations. Carbonate-chlorite-white mica schists (meta-dolostone) are generally associated with BIF. Phyllite, quartz-feldspar schist (meta-conglomerate), and a major quartzite unit overlie this volcanic-dominated sequence into which they are infolded.

Meta-gabbros occur as sill-like bodies within the meta-volcanic rocks in the northern and southern part of the map area (Fig. 2); an ultramafic rock mass (serpentinite) occurs associated with the meta-gabbros in the northern part of the map area.

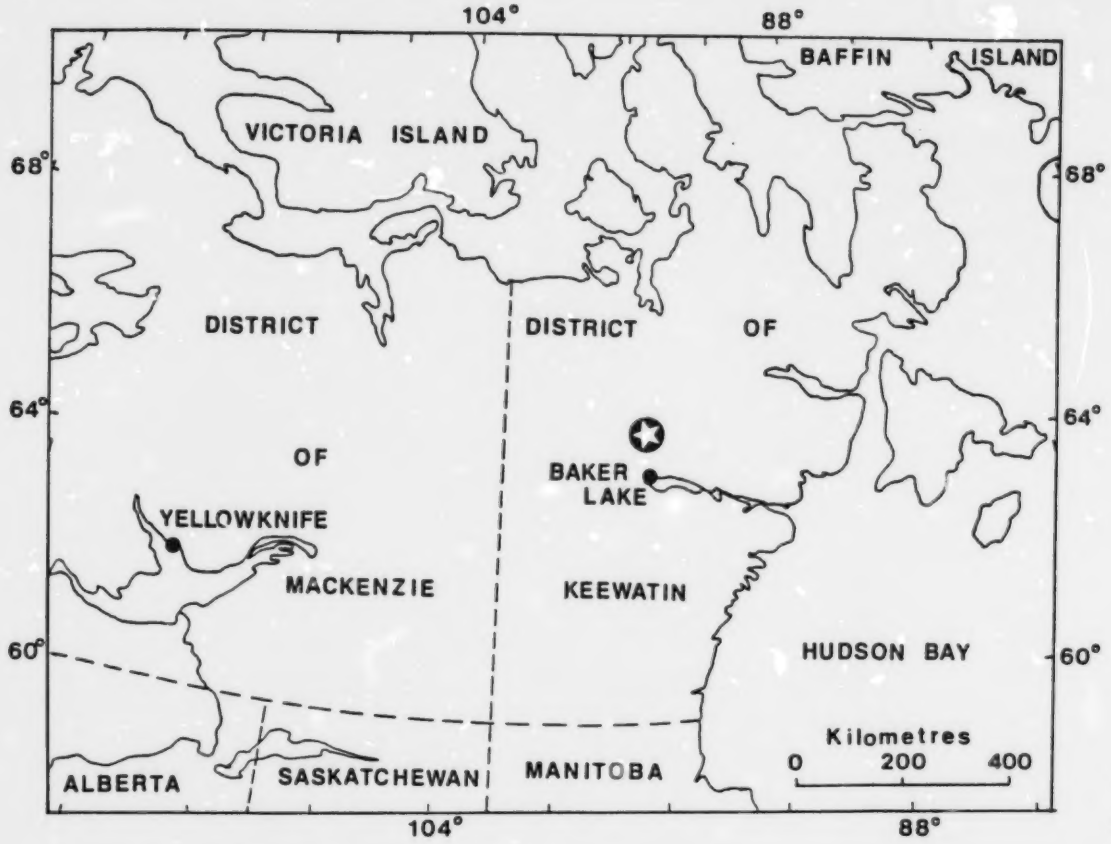


Figure 1. Map showing location of study area (star).

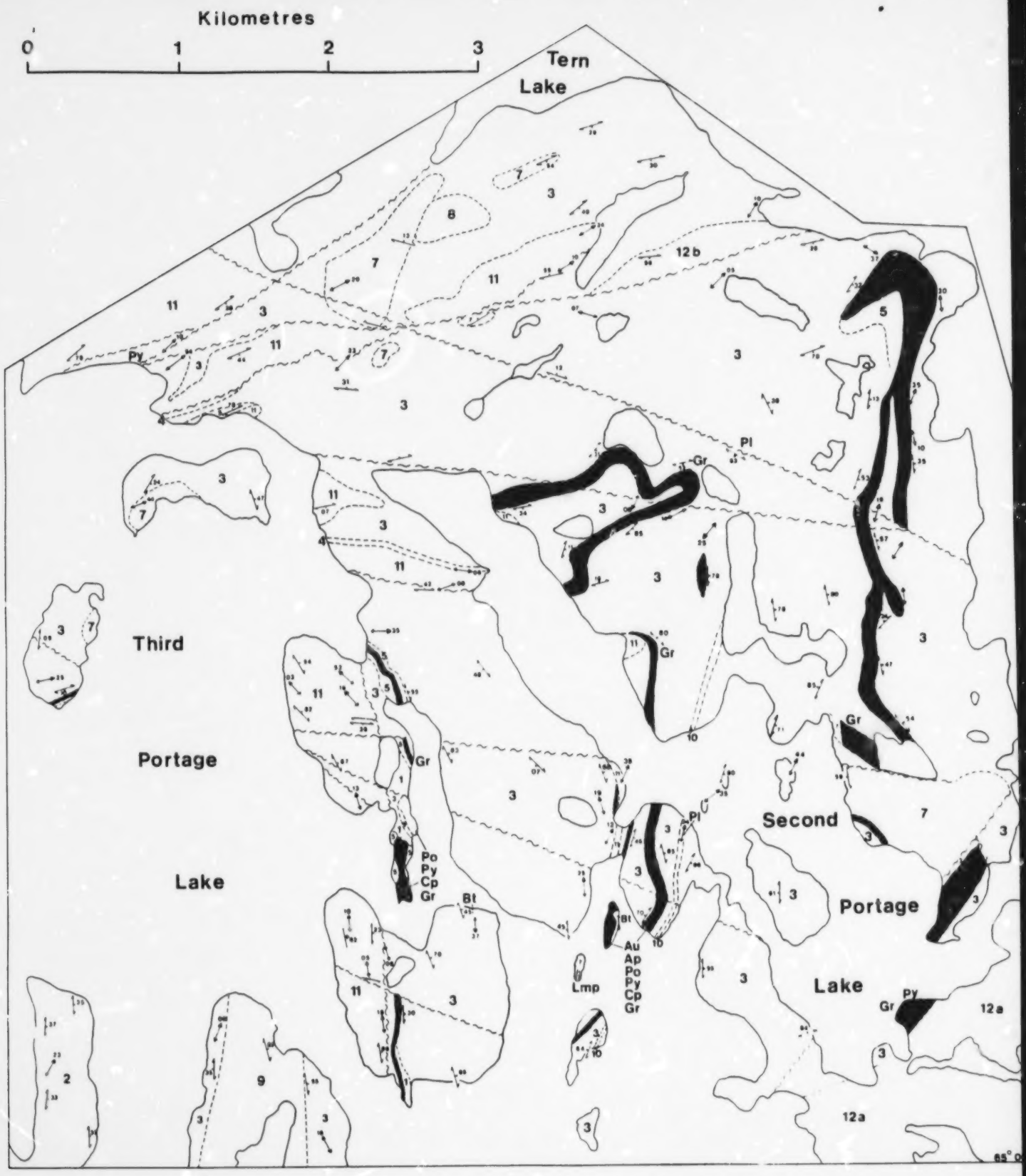


Figure 2. Geologic map of the Third Portage Lake area.

The meta-volcanic and meta-sedimentary rocks have been intruded by coarse grained granite plutons; these rocks are highly sheared in the northern part of the map area. A late lamprophyre dyke intrudes the meta-volcanic rocks in the southern part of the map area.

Primary layering (S_0) is preserved in the BIF, quartzite unit and phyllite. A regional foliation (S_1) forms parallel to this primary layering and is defined by the micas, chlorite and stilpnomelane. In many samples this S_1 fabric is cut at a high angle by a crenulation cleavage/foliation (S_2) defined by the same phases as well as grunerite.

The following is a detailed description of each unit identified in the map area.

MAFIC META-VOLCANIC UNIT

This unit occurs in a linear, discontinuous zone up to 0.4 kms wide and 2 kms long. It is associated with a unit of BIF and meta-dolostone on the east side of Third Portage Lake. Grain size in the northern part of the outcrop is fine- to medium-grained and coarsens southward probably in response to increasing metamorphic grade. Outlines of pillow-like structures are recognized in the lower grade rocks.

Amphibole (blue-green hornblende/tremolite), chlorite, $\pm$ biotite, plagioclase, and titanite constitute the stable mineral assemblage. In the higher grade rocks rosettes of hornblende crystals grow from elongate to circular zones of fine-grained xenoblastic amphibole which presumably has replaced primary igneous pyroxene. In these same rocks chlorite and accessory quantities of biotite and plagioclase fill the space between the amphibole. Colourless tremolite and chlorite form >90 modal % of the lower grade equivalents. Elsewhere rocks with this type of mineralogy have been classified as komatiites (Ashton, 1988) although it is unclear at this time if these rocks are ultramafic or high Mg volcanic rocks.

FELSIC META-VOLCANIC ROCKS

The felsic meta-volcanic rocks form the bedrock of a large island in Third Portage Lake in the southwest corner of the study area (Fig. 2). In hand specimen and outcrop scale they are light grey to pink in colour, aphanitic, and massive to weakly foliated. The rocks consist of quartz, albite, chlorite, white mica, biotite and epidote; these phases are fine- to medium-grained, and xeno- to subidioblastic. Calcite, titanite, and opaque minerals form accessory phases and K-feldspar and epidote occur along fracture and joint planes. Relict phenocrysts of plagioclase feldspar up to 2 mm in diameter are preserved as elongate, strained, partially recrystallized crystals in a foliated to slightly banded matrix of the metamorphic minerals. Micas and chlorite define the foliation; variations in grain size of felsic phases and concentrations of some mafic minerals into mm scale layers, define a discontinuous banding in the rock.

FELSIC META-VOLCANICLASTIC ROCKS

This is the most abundant rock unit in the map area. It varies from black to green to light grey, fine- to medium-grained and massive to foliated/schistose, or banded in terms of fabric. It is often unclear if the banded characteristic is a primary feature of the rock or a product of tectonism. All samples contain clasts of quartz and sodic plagioclase feldspar 0.4-2.0 mm in diameter, and totalling 20-40 modal %. Much of the feldspar has an original fresh tabular habit; composite grains are rare. In contrast quartz clasts appear to be more rounded and are more often quite completely replaced by an aggregate of finer grained xenoblastic crystals.

Legend for Figure 2

13 Lamprophyre (Lmp)

12 Granitic rocks
   a) coarse grained granite
   b) sheared granite

11 Quartzite unit

10 Quartz-feldspar schist, meta-conglomerate

9 Phyllite

8 Serpentinite

7 Meta-gabbros

6 Banded magnetite-chert iron formation (BIF) (blacked in)

5 Carbonate-chlorite-white mica schist (meta-dolostone)

4 Chlorite-epidote-carbonate schist

3 Felsic meta-volcaniclastic unit

2 Felsic meta-volcanic rocks

1 Mafic meta-volcanic rocks

Map Symbols

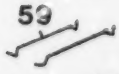
--- Lithologic contact

~~ Fault

Bedding (inclined upright)

Foliation (inclined)

Shearing



Movement sense unknown (inclined, dip unknown)

Fold axis (plunge known)

Bt Biotite porphyroblast

Pl Plagioclase porphyroblast

Gr Grunerite

Au Anomalous gold assay

Py Pyrite

Po Pyrrhotite

Cp Chalcopyrite

Ap Arsenopyrite

Massive to weakly foliated samples are typically grey to black and are widely dispersed throughout the map area. The stable assemblage is quartz + albite + white mica + chlorite + epidote ± biotite, calcite, tourmaline and accessory titanite, zircon, apatite and opaque minerals including disseminated pyrite cubes. In these rocks the clasts of plagioclase and quartz are suspended in a fine-grained weakly foliated metamorphic matrix of quartz, albite, white mica, chlorite, ± carbonate, epidote, and fine- to medium-grained porphyroblastic biotite. In a few samples mm thick, discontinuous lenses of feldspar clasts in a fine-grained quartz ± white mica matrix are observed. In equally rare cases thin white mica-rich lenses are oriented in sets so as to resemble cross beds. These features suggest a deep water epiclastic origin for some of these rocks; the larger group are considered to be crystal tuffs.

In the region between Second and Third Portage Lake (Fig. 2) and on the larger island in Third Portage Lake, the rocks are often strongly foliated or banded. Carbonate, chlorite and in one sample, tourmaline are noticeable more abundant in these rocks. Clasts of quartz and plagioclase are often oriented with long axis parallel to the foliation plane. Pressure shadows of quartz and carbonate are common and the metamorphic foliation defined by chlorite, mica and carbonate wraps around these clastic grains. Layering in these rocks is due to the presence of continuous to discontinuous bands of mineralogically distinctive assemblages including; (1) quartz + carbonate + minor feldspar and chlorite 1-2 mm thick and (2) thin discontinuous layers of chlorite + white mica ± tourmaline and rutile. Layer boundaries are normally sharp. The degree of deformation that the sample has undergone is typically recorded by the asymmetric microfolds that these thin layers record. Deformation of the S_0/S_1 fabric due to an F_2 event, occasionally forms a weak S_2 axial planar cleavage similar to that common in the more pelitic rocks of the region.

Green grey rocks mainly outcrop between Tern and Third Portage Lake. These rocks are more homogeneous than the previous mentioned types but some foliation is defined by more chlorite and white mica-rich layers. Mineralogically these rocks are similar to the rest of the rocks in this unit although plagioclase is more abundant and lenses of feldspar clasts are not observed.

CHLORITE - EPIDOTE - CARBONATE SCHISTS

Rocks included in this unit occur as isolated outcrops normally wholly within the felsic meta-volcaniclastic unit. In a few instances they occur as narrow units adjacent to the quartzites (Fig. 2). Samples are light to dark grey in colour, fine-grained for the most part, and vary from layered to massive on a megascopic scale.

On a microscopic scale layering is defined by alternating bands consisting of (1) carbonate and quartz with accessory epidote, chlorite, biotite, and iron oxides and (2) mafic bands of chlorite, epidote, plagioclase and accessory biotite, quartz, and iron oxide. White mica may be present as a dispersed phases or as thin discontinuous layers. Layer thickness varies from 0.5-8 mm. Recrystallized clasts of quartz and/or feldspar may occur in either layer type. If the layering has a sedimentary origin S_0 and S_1 are approximately parallel, the latter being defined by the alignment of chlorite particularly in the more mafic layers. Symmetric to asymmetric open to isoclinal folding results in the formation of a weak S_2 fabric. In one sample this S_2 fabric is very prominent where it is defined by chlorite; syn- to post-S_2 blue-green hornblende porphyroblasts and late pyrite octahedra are prominent in this sample.

These rocks may represent either more mafic layers associated with the volcaniclastic unit or sheared mafic dikes and sills within the volcaniclastic unit. It is unclear whether the banding in these rocks has a tectonic or sedimentary origin.

CARBONATE-CHLORITE-WHITE MICA SCHISTS (META-DOLOSTONE)

These rocks form discontinuous units generally associated with the iron formations on the east side of Third Portage Lake (Fig. 2) and south of Tern Lake. Minor outcrops occur at the north end of Third Portage Lake and between Second and Third Portage Lake. On weathered surface samples are pale green-grey to brown in colour and vary from strongly foliated to massive; the latter type has the highest carbonate and quartz content and only a small sheet silicate content.

The rocks from the Tern Lake area show what may be relic layering defined by white mica + chlorite alternating with quartz + carbonate layers. S_0/S_1 structures have been tightly folded and have become discontinuous. In all samples, a strong S_2 axial planar foliation is present, defined by chlorite and white mica. The samples from the Third Portage Lake area are generally more thoroughly recrystallized and do not exhibit a layered structure. They vary from quite massive to strongly foliated; linear discontinuous zones of fine-grained quartz, chlorite and mica $\pm$ tourmaline and biotite dissect a coarse aggregate of carbonate, quartz and minor sheet silicates. In thin section and on the hand specimen scale these samples can be confused with hydrothermal carbonate vein system material. The area from which these samples come has experienced a higher grade of metamorphism and so relic structures and fabrics are rarely preserved.

BANDED MAGNETITE-CHERT IRON FORMATION (BIF)

BIF occurs throughout the map area as continuous to discontinuous layers 75-100 m thick on surface, interlayered with rocks from the volcaniclastic unit and less commonly with mafic metavolcanic rocks and chlorite-carbonate-white mica schists. They crop out as a continuous band from Tern Lake to the north end of Second Portage Lake and as two bands on the eastern mainland and islands of Third Portage lake.

Fine grained idioblastic magnetite and xenoblastic quartz as separate bands 1 mm - 2 cm in thickness form 99 modal % of the least deformed and metamorphosed BIF in this area; these rocks characterize the BIF in the northeast part of the region. Green pleochroic chlorite, white mica, porphyroblastic ankerite, scarce stilpnomelane, a red-brown, high relief phase which forms stubby equant crystals, and pyrite octahedra and cubes, are other phases in these rocks. In one sample in which stilpnomelane, white mica and carbonate are major phases with quartz and magnetite. In a few samples abrupt change of grain size of quartz from very fine to fine within a quartz layer is taken to be a relic sedimentary feature as is the compositional banding of the rock. Very fine magnetite laminae accompany the finer grained quartz. Thin discontinuous lenses of chlorite may occur at the interface between quartz and magnetite layers. South and west of the Tern Lake area some samples of the BIF exhibit open to near isoclinal, symmetric to asymmetric microfolds; in these samples an axial planar cleavage may occur where the folds are tightest. Fibrous stilpnomelane and chlorite form in these zones to delineate an S_2 fabric distinct from the S_0/S_1 bedding/foliation.

South and west of Tern Lake (Fig. 2) the degree of deformation and metamorphic recrystallization of the BIF increases although by no means in a simple systematic way. At the present time we are unable to delineate metamorphic grade by regular isograd boundaries. In most of the BIF immediately north of the north side of Second Portage Lake well formed stilpnomelane and fibrous sprays of grunerite are common in many samples. In fractures/cleavages oriented perpendicular to S_0/S_1 thin fibrous stilpnomelane forms an elongate core from which fibrous grunerite radiates into a quartz-rich matrix. Coarser grained stilpnomelane occurs in small clusters elsewhere in the quartz-rich layers; a red-brown high-

relief phase ± magnetite is also present. In the magnetite-rich layers stilpnomelane ± colourless chlorite and quartz is common and often abundant. Grunerite also commonly occurs at the magnetite-quartz layer interfaces where it grows perpendicular to the layer boundary. In one sample a layer of magnetite, iron carbonate (siderite), and a red-brown phase are separated from the grunerite-type amphibole ± stilpnomelane.

In the southern half of the map area grunerite, as elliptical to ovoid radiating clusters 1-4 mm in diameter within both quartz and magnetite layers, form a dominant feature of these rocks. In many instances the amphibole distribution is related to microfractures within the quartz layers; these fractures are often not apparently related to a deformation event. Those samples with the most abundant grunerite typically contain the least magnetite; fine to coarse grunerite needles grow into and eventually enclose the quartz zones. Quartz in such samples is fine- to medium-grained and exhibits a granoblastic, polygonal texture. Carbonate (siderite/ankerite), coarse idioblastic magnetite, stilpnomelane, and green, pleochroic alkali amphibole (as rims on grunerite in the most recrystallized samples) are other common phases in these rocks. All of the samples described here are at best only mildly folded by an F_2 deformation event; none show the strong S_2 crenulation cleavage that is observed in rocks of pelitic composition.

At the contact with the younger granite intrusion in the south-east corner of the map area, BIF consists of very coarse-grained grunerite, 2-4 mm in length, interlayered with mm wide bands of magnetite. This assemblage has been disrupted by later fluids forming fine grained granoblastic grunerite veinlets 0.2 -2.5mm in width which randomly cut and recrystallize the pre-existing assemblage. Pyrite occupies the central portions of the larger of these veins. Both generations of grunerite are probably related to the emplacement of the adjacent igneous intrusion.

METAGABBRO, MAFIC SCHIST

Relict textures indicate that these rocks initially formed as plagioclase-pyroxene cumulates with medium- to coarse-grained euhedral crystals. Throughout the map area these rocks occur as sill-like bodies up to 2 kms in length and 0.25-0.5 kms wide. In outcrop they weather light to dark green; at the megascopic scale they are texturally heterogeneous due to the presence of narrow linear zones of strongly foliated rocks which normally characterize the margins of the sills (southern gabbros) but may also penetrate throughout the bodies (northern gabbros).

The gabbros now consist of the assemblage actinolite/blue-green hornblende + epidote/clinozoisite + chlorite + plagioclase (albite-oligoclase) ± quartz, calcite, white mica, biotite and accessory titanite and opaque minerals including pyrite. In nonfoliated samples, amphibole pseudomorphs after pyroxene and fine grained aggregates of clinozoisite, sodic plagioclase, chlorite, mica, and quartz after plagioclase, characterize the rocks. Relic igneous Fe-Ti oxides are typically rimmed or replaced by titanite. In the northern portion of the map area actinolite is the stable metamorphic amphibole; in contrast, blue-green hornblende, either as distinct crystals or as narrow rims at plagioclase-actinolite boundaries is more typical of the mineralogy of these rocks in the southern part of the region. In these latter rocks the metamorphic feldspar (with clinozoisite etc.) often occurs as clusters of fine-grained xenoblastic crystals. This texture and the appearance of blue-green hornblende indicates a higher metamorphic grade in the southern portion of the map area. In some samples medium to coarse aggregates of epidote and chlorite occur in areas between the amphibole - feldspar zones.

The foliated and banded mafic schists consist of quartz, chlorite, plagioclase (albite), calcite/ankerite, white mica, titanite, ± epidote. Relic igneous textures are absent. The banded samples have chlorite and titanite-rich layers alternating with layers of quartz, plagioclase, and carbonate. These rocks are conspicuous for their absence of amphibole and clinozoisite due probably to low temperature recrystallization in the presence of a CO_2-rich fluid.

Fractures within the gabbro bodies are often occupied by vein material. Quartz and carbonate minerals dominate these assemblages in the northern gabbros; veins in the southern gabbros consist of potassic feldspar, chlorite and epidote probably reflecting proximity to younger igneous granitic rocks.

SERPENTINITE

A weakly foliated ultramafic rock mass approximately 0.8 kms in diameter crops out in the north-central portion of the map area in the same vicinity as the northern gabbros. Contacts between the two units were not observed. These rocks are dense, magnetic, weather green to black in colour, and contain veins of asbestos serpentine and talc up to 6 cm in width. A weak foliation in the rock is defined by the alignment of rods (0.5-2 mm in length) of magnetite which forms up to 5 modal % of a sample. Serpentine (70 %) occurs as equant-shaped hour-glass structures 0.2-1.0 mm in diameter within a more dominant mass of mesh-textured fibrous serpentine, which appears to outline relict olivine grains. Carbonate occurs as xenoblastic clusters of crystals up to 1.0 mm in diameter randomly distributed throughout the rock; it can also occur as elongate bands parallel to the rods of iron oxide. Talc is a minor phase (2-3 modal %). The high proportion of serpentine and absence of calcic amphibole suggest that this unit may have been a dunite body.

PHYLLITE

This unit crops out in an area 1/2 X 3 kms in dimensions in the SW portion of the map area. Megascopically these rocks range from light to dark grey in colour depending on quartz content. They are very fine- to fine-grained, and exhibit a strong foliation. Normally bedding is not observed.

The equilibrium mineral paragenesis is quartz, white mica, biotite and stilpnomelane and accessory ilmenite and pyrite. Millimetre thick, discontinuous quartz-rich layers are occasionally observed preserving a folded S_0 fabric; in isoclinal symmetric to more open asymmetric microfolds S_1 is defined by white mica parallel to S_0. In all samples this S_1 fabric is cut at a high angle by a strong crenulation cleavage/foliation defining S_2. This is the megascopic fabric of the rock. White mica, biotite and stilpnomelane lie within and define the orientation of the S_2 fabric. In one sample linear, mica rich S_2 zones, 1-3 mm wide, bound S_1 microfolds of similar or thinner dimensions. Stilpnomelane occurs in thin clusters of interleaved microveinlets parallel to S_2.

QUARTZ - FELDSPAR SCHISTS, METACONGLOMERATE

Rocks in this unit form a linear band which can be traced over a distance of 3.5 kms from an island in the east side of Third Portage Lake in a northerly direction. The unit has an estimated thickness of 10 m in plan view and in outcrop is a light grey colour on fresh and weathered surfaces. Contacts with adjacent units are not exposed although it bears similarities to a unit characteristic of the base of the quartzites as described by Ashton (1988). Megascopic

features that characterize these rocks are the presence of quartz clasts (2-6 mm in diameter), occasional appearance of feldspar porphyroblasts, and in some samples the presence of small-scale microfolds and an associated crenulation cleavage.

The assemblage quartz + plagioclase (albite-oligoclase) + white mica ± biotite, chlorite and pyrite and other opaque minerals forms the typical equilibrium paragenesis. Quartz clasts, variously recrystallized, are common in these rocks which often show a weak sedimentary layering normally due to grain size variations in quartz. Syntectonic plagioclase porphyroblasts with excellent rotated inclusion trains of quartz are common in psammitic rock compositions in the smaller outcrops between Second and Third Portage Lake; these rocks normally have no relic sedimentary structures aside from occasional quartz clasts. In one sample particularly rich in white mica, an excellent axial planar crenulation cleavage (S_2) has formed; in this sample post-tectonic biotite porphyroblasts, vein-like zones of quartz, biotite and plagioclase, and late pyrite are common.

QUARTZITE UNIT

This unit forms 20-50 m high, elongate weather-resistant ridges in the northern and western part of the map area and a few low-lying scattered outcrops elsewhere in the map area. The unit consists of meta-orthoquartzite and a small proportion of quartz-white mica schist, the latter as thin, discontinuous lenses most often occurring at the exposed margins of the quartzite unit. Megascopic-scale bedding and other primary structures are not observed in the quartzitic rocks. Both rock types are white on fresh and weathered surfaces; typically the quartzite has <20 modal % whereas the mica schist contains 30-45%.

The stable mineral paragenesis for these rocks is quartz + white mica ± tourmaline and stilpnomelane, and accessory amounts of titanite, zircon, magnetite and pyrite. At the microscopic scale some samples show layers with sharp boundaries l-5 mm thick, distinguished by variations in grain size of quartz and/or white mica content. Tourmaline is locally very abundant in some layers as needles oriented parallel to the layer boundary. Quartz occurs as xenoblastic crystals with undulose extinction and sutured grain boundaries. It is typically fine- to medium-grained but also forms clasts 0.5-3 mm in diameter within orthoquartzite layers. Much of the quartz appears to be slightly elongate parallel to a weak axial planar crenulation cleavage whose orientation is at a high angle to the bedding plane (S_0). White mica is similarly fine to medium grained, subidioblastic, and defines two foliations. The most prominent is a penetrative type, parallel to bedding and is designated S_1. This foliation has been folded in an asymmetric style; in the noses of these microfolds, axial planar S_2 white mica is observed sporadically and not in all samples. Very fine grained quartz and stilpnomelane (one sample) may also lie in these zones.

Three samples of very mica-rich schist show additional features that are noteworthy. Two of these samples are very similar to rocks described above but in addition show a well developed S_2 penetrative crenulation cleavage and in both samples moderate to abundant pyrite mineralization is very noticeable and often best formed in and close to cleavage. One sample from the west side of Second Portage Lake (Fig. 2) contains layers of magnetite 1-2 mm thick.

GRANITIC ROCKS

Archean (2621 ± 2 Ma; Ashton 1988) coarse grained granite intrudes the supracrustal volcanic/sedimentary sequence in the Amer Lake area (Ashton ibid). These rocks consist of quartz, perthitic microcline, albitic plagioclase, biotite, chlorite and epidote with accessory apatite,

zircon, purple fluorite, sphene, secondary white mica, carbonate and locally hematized opaque minerals. Minor granophyre is also observed. These rocks crop out in the extreme south east corner of the map area where they are massive to weakly foliated, weather pink, and contain up to 10 modal % mafic minerals.

Other igneous rocks crop out in the northern part of the map area immediately south of Tern Lake (Fig. 2); these rocks were named the Tern Lake Porphyry (Ashton 1988). They typically exhibit a strong foliated megascopic fabric and vary from fine- to medium-grained. In thin section the samples are seen to consist of porphyroclasts of quartz, plagioclase and microcline perthite enclosed by a foliated, fine grained matrix of the same phases and biotite, chlorite and white mica; minor granophyre is also present. Porphyroclasts range from 1-8mm in diameter and form up to 65% of the rock. The shearing is observed to extend throughout this rock unit; no contacts were observed with the felsic meta-volcaniclastic sequence.

LAMPROPHYRE

On a small island in the southern part of the map area (Fig. 2), a 1m wide north-south trending lamprophyre dyke was identified within meta-gabbro. The lamprophyre consists of biotite, apatite, quartz, calcite, and plagioclase. Biotite (65 modal %) and apatite (15 modal %) occur as medium-grained, subhedral phenocrysts, weakly aligned, giving the rock a slightly foliated fabric. Anhedral quartz and calcite, euhedral garnet and subhedral plagioclase are additional phases in a fine-grained massive matrix. The plagioclase exhibits a faint pink pleochroism and contains inclusions of fine needles of rutile. Based on its mineralogy, the lamprophyry is interpreted to be a Kersantite according to the I.U.G.S. classification (Streckeisen 1980).

Ashton (1988) suggests the lamprophyres in the area belong to the Aphebian Dubawnt Group lamprophyre swarm(s).

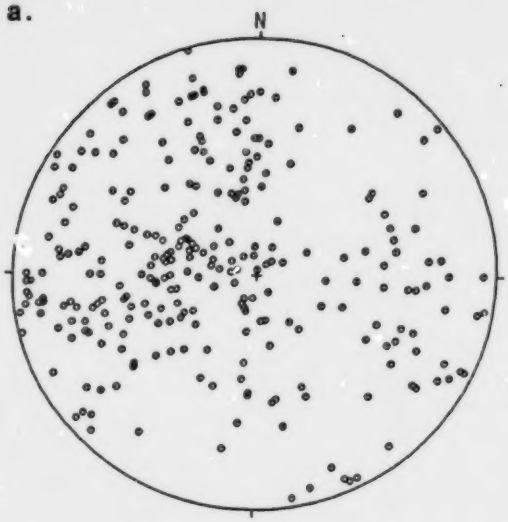
STRUCTURE

Ashton (1988) has described the structure of the Woodburn Lake Group in the southern half of the Amer Lake map sheet. The present study area constitutes a part of this region. His study identifies six phases of deformation; each is described below. The present study is related to this regional structure by using the same notation to identify each deformational event.

The sequence of deformational events recognized by Ashton (1988) is as follows: (S_0) is primary layering); D_1-D_3 include the first major deformational event. The main regional foliation (S_1) is defined by northeast-striking lithological contacts, compositional layering and schistosity and/or cleavage; schistosity is defined by the alignment of amphibole, biotite, chlorite and or white mica. This is part of the first phase of deformation (D_1). The regional foliation is axial planer to an initial phase of tight to isoclinal folding (L_1). The second phase of deformation (D_2) is indicated by a weak south-southeast dipping schistosity (S_2) identified in several rock-types. Intersections of S_1 and S_2 define L_2 lineations. D_3 is defined by a steeply south-dipping schistosity in the northern granites.

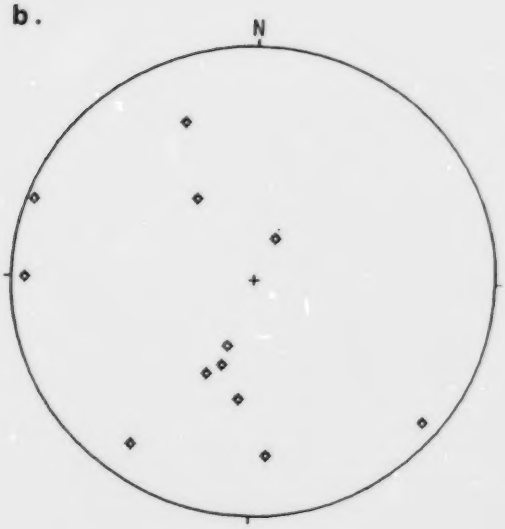
A second major deformational event (D_4-D_6) produced layer-parallel ductile shear zones (S_4) as well as northeast-, southeast-, and south-plunging megascopic folding and gentle northeast- and southwest-plunging to horizontal crenulations. The shear zones are particularly common along contacts between the volcanic suite rocks and quartzite sequence. Cross-cutting

a.



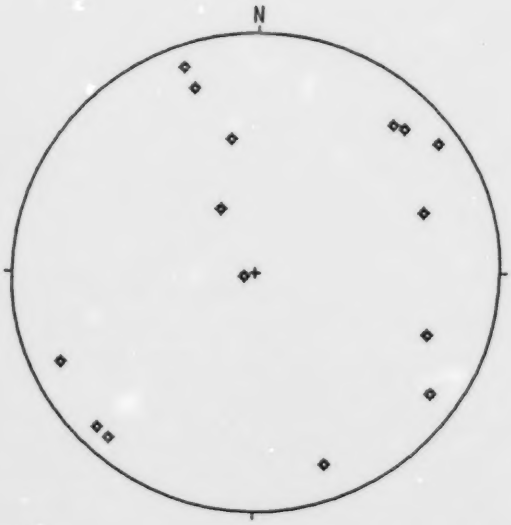
Projection ..... Schmidt
Number of Sample Points 287

b.



Projection ..... Schmidt
Number of Sample Points 12

Figure 3. Stereonet plot of poles to a. S_1, and b. S_2 foliation.



Projection ..... Schmidt
Number of Sample Points 15

Figure 4. Stereonet plot of intersection lineations (L_2) of S_1 and S_2 foliations.

shear zones (S_s), kink folds, and rare broad open megascopic folds (L_s) formed as deformation continued. North and west-northwest striking brittle faults (S_s) form a set of conjugate strike-slip faults.

The main tectonic elements identified in the Third Portage Lake area include foliations and fold axes. Other less prominent elements identified include axial planes, joints, axes of crenulations, intersection lineations, and fault and shear zone trends. Bedding is observed in the quartzite and BIF.

Bedding (S_0) in the BIF is indicated by alternating layers of chert and magnetite. Bedding in the quartzites and phyllites is indicated by layers of mica-rich and mica-poor layers. Microscopically, layers are also identified by variations in grain size.

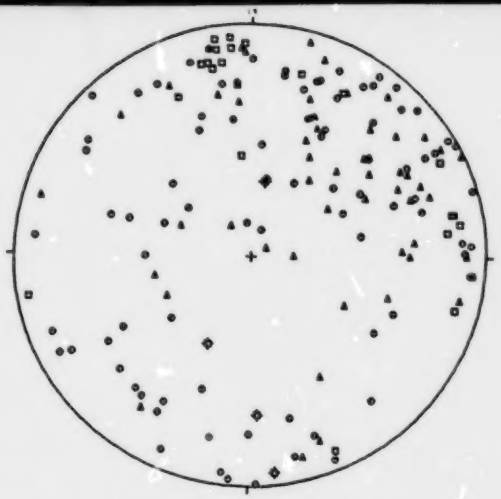
The main regional foliation (S_1) is variable in the study area (Fig. 3a). The foliation in the rocks is defined by micas and chlorite and rarely by amphiboles in the mafic rocks. It strikes mainly northeast-northwest (320°-020°) in the southern half of the map area (Fig. 2) and dips at a shallow to steep angle (09°-86°) to the east with local variations. In the northern half of the study area it strikes east-northeast (40°-85°) (Fig. 2) and dips steep to shallow (87°-15°) to the south; this foliation trend is parallel to the regional foliation defined by Ashton (1988).

A weak second foliation (S_2) was observed in the study area which formed oblique (60°) to the S1 foliation (Fig. 3b). It is recognized in the quartzite unit, the felsic meta-volcaniclastic rocks, and BIF and shows a moderate to steeply dipping (32°-88°) northeast to west strike. This foliation is more prominent in thin section where the micas and chlorite form a crenulation cleavage/foliation at a high angle to the S_1 foliation. Porphyroblastic growth in some rocks between Second and Third Portage Lakes appear to be syntectonic with the development of this second foliation. This includes feldspar and mica growth in some felsic meta-volcaniclastic rocks. The growth of amphibole (grunerite) in the BIF in the southern half of the map area appears also to be related to the formation of this second foliation. This mineral growth may be attributed to the emplacement of the coarse grained granite in the south (Fig. 2). The intersection lineation, L_2, of S_1 and S_2 has a highly variable orientation (Fig.4).

Folds in the study area vary in type and orientation (Fig. 5). Gentle to moderate (05°-63°) north and south plunging isoclinal folds (L_1) are rare but were observed in an outcrop of BIF between Second and Third Portage Lake and the felsic volcaniclastic unit on the large island in Third Portage Lake. They are axial planer to the main regional foliation (S_1). Closed to tight folds ($L_{2/3/4}$) generally show gentle to moderate north, northeast, and east plunging fold axes with both S and Z asymmetry. These folds fold the regional foliation and may be attributed to $D_{2/3/4}$ phases of deformation of Ashton (1988).

Conical folds (L_4) were observed at the base of the quartzites in most locations. Ashton (1988) refers to these as drag folds. These exhibit gentle plunging axes (05°-26°) (Fig. 5) which tend to parallel the trend bedding/foliation of the quartzite units. Other folds characteristic of these zones are folds possessing one steep limb and one shallow limb with a shallow fold axis. These folds and the conical folds indicate near vertical movement along the contacts between the quartzite unit and meta-volcanic sequence (Fig. 2).

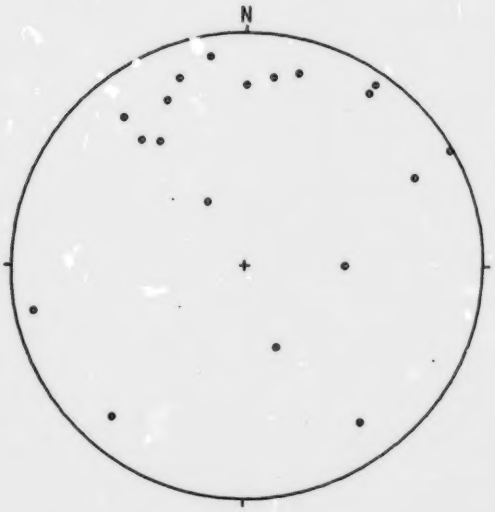
Along the western shoreline of Second Portage Lake, a zone of quartzite with layers of magnetite 1-2mm thick grades into mature quartzite. Chlorite schists were found near the base of the magnetite-bearing quartzite associated as well as at the north end of Third Portage Lake. These rocks may also indicate movement along these contacts.



Projection ..... Schmidt
Number of Sample Points 166

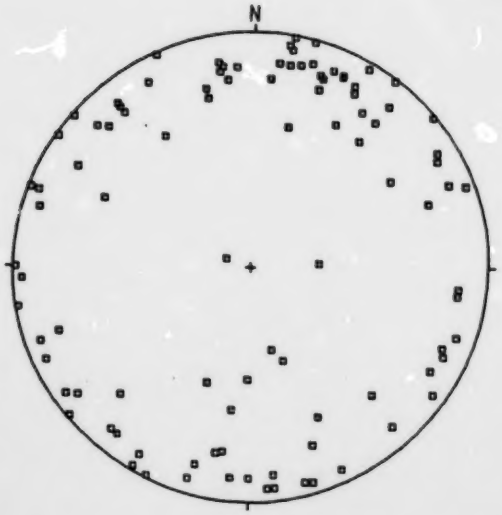
- isoclinal folds (L_1)
- Tight to closed folds ($L_{2/3/4}$)
- Conical folds (L_4)
- Open folds (L_5)

Figure 5. Stereonet plot of trend of fold axes.



Projection ..... Schmidt
Number of Sample Points 19

Figure 6. Stereonet plot of crenulation lineations (L_4).



Projection ..... Schmidt
Number of Sample Points 99

Figure 7. Stereonet plot of poles to joint planes.

Crenulation lineations (L_4, Fig. 6) were identified in various locations, mainly in the quartzite unit. They show a general shallow-plunging (05°-30°) north-northeast trend (320°-015°) with some local extreme variations.

Late cross-cutting shear zones (L_5) are present in the north and south of the map area (Fig. 2). These shear zones affect the granitic unit and meta-gabbros in the northern part of the map area and the meta-gabbro in the southern part of the map area. They are indicated by the quartz-carbonate and chlorite banding in the meta-gabbros and the strong foliated, porphyroclastic texture in the northern granitic unit. Kink folds were also identified in the northern meta-gabbros.

Ashton (1988) describes two megascopic synforms in the Portage Lake area. These include a southwest-plunging D_4 synform extending from southeastern Tern Lake to Second Portage Lake and a tight, south plunging D_5 synform between Second and Third Portage Lakes. The trends of the foliations and fold axes recognized in this study support the existence of these structures but it is not clear if they are synforms or antiforms. Broad open mesoscopic folds (L_5, Fig. 5) are identified throughout the area with fold axis showing gentle to moderate dipping (05°-40°) northwest to northeast trending (337°-70°) fold axes. These folds tend to fold the S_1 and S_2 foliations and other pre-existing folds.

Several late west and north-northwest trending brittle faults (S_6, fig. 2) were identified in the Quartzites and BIF but are inferred to posses limited offset. Other faults are inferred from linear trends and breaks in the more resistant units ie; the quartzites and iron formations.

Joint plane orientations were measured throughout the study area but there orientations were scattered and no single joint set was identified (Fig. 7). Jointing is more prominent in the southern half of the map area; epidote and K-feldspar are on some joint planes. The formation of the joints and veining is attributed to the emplacement of the coarse grained granite.

METAMORPHISM

BIF throughout the area shows a systematic variation in mineralogy that has been recognized as indicative of change in metamorphic grade. The BIF adjacent to Tern Lake (Fig. 2) and those south and west of Tern Lake contain small amounts of green pleochroic chlorite and stilpnomelane typical of the sub-biotite zone of Klein (1983). BIF from elsewhere in the study area contains grunerite which Klein (1983) classifies as typical of biotite zone metamorphic grade. In these rocks grain size coarsens, equilibrium grain boundaries become dominant, and small amounts of alkali amphibole with the grunerite appears towards the south and west boundaries of the region.

The meta-gabbros from the northern part of the map area (Fig. 2) contain pale green pleochroic actinolite indicating a lower greenschist grade of metamorphism. Similar rocks in the southern half of the region have monoclinic amphiboles which often exhibit a pale blue-green pleochroism typical of actinolitic hornblendes indicative of upper greenschist grade and consistent with the BIF data. These amphiboles have a very patchy extinction due to the intergrowth of actinolite and hornblende reflecting a low temperature solvus relation. Blue-green hornblende in the mafic meta-volcanic rocks on the east side of Third Portage Lake (Fig. 2) also suggests an upper greenschist grade in the southern part of the map area.

The felsic meta-volcaniclastic rocks have a psammitic rock composition. Biotite is a typical phase in these rocks except in an elongate zone in the central part of the map area where sub-biotite zone BIF has been recognized. Post S_2 porphyroblastic biotite occurs in

many samples from the southern part of the map area (Fig. 2). In several samples from the central region of the map syntectonic porphyroblasts of plagioclase with rotated inclusion trains of quartz are associated with syn- to post-tectonic biotite. These rocks are spatially related to the BIF containing abundant grunerite growth.

Rocks classified as phyllites or mica schists have semi-pelitic compositions; they occur in the southwestern portion of the map area and as thin units within the felsic meta-volcaniclastic rocks. Except in the most northerly reaches of the map area, biotite with chlorite and white mica is a dominant association indicative of at least middle greenschist facies conditions.

These data indicate that on a regional scale metamorphic grade increases from lower to at least middle greenschist facies grade from north to south in the map area. One sample of BIF at the contact with the coarse grained granite (Fig. 2) has a hornfelsic texture attesting to the presence of a contact aureole and suggesting that it may be the source of heat responsible for the rise in regional grade as described above.

ECONOMIC POTENTIAL

In the summer of 1989 prior to the start of this study, Comaplex Minerals Corporation initiated an exploration and drilling program of auriferous BIF which included the study area and is the focus of this report. The drilling was centred in the BIF in the south-central part of the map area on a peninsula separating Second and Third Portage Lakes (Fig. 2). Our data has verified that BIF in the map area contains sulphide mineralization at several localities, a few of which contain anomalous Au concentrations. Below we describe the features of this mineralization noting that our sample population (33) is small and therefore our interpretations subject to change as more data is collected.

Gossan occurrences in the BIF are restricted to the southern half of the region. Pyrite, pyrrhotite, and very scarce arsenopyrite and chalcopyrite are the sulphide phases in these samples, normally in modal amounts << 1 %. As described in the section on metamorphism, grunerite is a common phase in the BIF of this area and although it is often present in auriferous samples it is not an essential ingredient to mineralized samples. A critical feature of the mineralized samples is the presence of late, discontinuous, sulphide veinlets and patches ($\pm$ chlorite, grunerite, quartz) in quartz-rich layers and oriented at a high angle to the banding (S_0) in the sample.

BIF from the northeast part of the map (Fig. 2) area contains only very scarce idioblastic pyrite and xenoblastic chalcopyrite within quartz-rich layers; veining in these rocks is minor or absent and unrelated to the sulphide minerals. In BIF samples from the central and southern part of the region, pyrite and pyrrhotite occurs as fine grained clusters of xenoblastic crystals and discontinuous, layer-parallel veinlets within magnetite-rich layers of grunerite-bearing BIF. Magnetite grains in these samples often contain inclusions of pyrrhotite, pyrite and chalcopyrite. While this material can be quite sulphide-rich, assay data show conclusively that they contain essentially no Au ie: < 0.001 oz/ton. The band of iron formation along the east shore of Third Portage Lake is typical of this scenario. Those samples of BIF which are mineralized (> 0.02 oz/ton Au) consist of discontinuous/disrupted iron oxide-silicate bands within which veinlets of quartz in the magnetite layers and sulphides ($\pm$ chlorite, grunerite) in quartz layers, are oriented near perpendicular to S_0. This type of veining is diagnostic of the mineralized samples; pyrrhotite with magnetite and rarely arsenopyrite with magnetite are the phases in these veinlets. In age this type of sulphide mineralization is recognized as syn-post S_2.

Assays for gold and arsenic were done on 33 samples of the BIF from throughout the map area. Values of >580 ppb with a maximum of 1380 ppb (>.017 oz/T, maximum .04 oz/T)

for gold and >180 ppm (maximum of 290 ppm) arsenic are spatially associated with the BIF in the peninsula area between Second and Third Portage Lake (Fig. 2). Outside of this area, gold values decrease to <35 ppb and arsenic values to <15 ppm.

Gossans due to pyrite mineralization in the quartzite unit are exposed at the north end of Third Portage Lake. This mineralization appears to be associated with the late brittle faults (S_e). Pyrite also occurs in the BIF at the contact with the granite body in the southern part of the area. This mineralization is in veins which appear to be associated with late faulting.

Pyrite cubes up to 1 cm in diameter were associated with the lamprophyry dyke in the southern part of the map area (Fig. 2). The pyrite occurred in a zone in the host meta-gabbro extending for 1 m on either side of the dyke. This suggests the presence of sulphur rich fluids associated with the dyke.

References

Ashton, K. E. 1988. Precambrian geology of the southeastern Amer Lake area (66H/1, near Baker Lake, N.W.T.. A study of the Woodburn Lake Group, an Archean, orthoquartzite bearing sequence in the Churchill Structural Province. A Phd thesis, Queen's University, Kingston Ontario, Canada.

Hoffman, Paul F. 1988. United Plates of America, the Birth of a Craton: Early Proterozoic Assembly and Growth of Laurentia. Ann. Rev. Earth Planet. Sci., 16, 543-603.

Klein, C. 1983. Diagenesis and metamorphism of Precambrian Banded iron-formations. In iron formations: facts and problems. Edited by A. F. Trendall, Elsvier, New York, NY.

Streckeisen, A. 1980. Classification and nomenclature of Volcanic Rocks, Lamprophyres, Carbonatites and Melilitic Rocks. IUGS Subcommission on the Systematics of Igneous Rocks, recommendations and suggestions. Geol. Rundschau, 69, 194-207.